

## REMARKS

In response to Examiner rejections, Claims 12, 34, 45, 121, and 134 are hereby amended. Claims 1-11, 26-33, 36-44, and 87-105 drawn to a non-elected species are currently withdrawn from consideration. Claims 12-16, 18-25, 34-35, 45-54, and 106-136 are currently pending and under consideration. Reexamination and reconsideration of the application, as amended, are respectfully requested.

Amendments to the specification have been made to explicitly recite limitations inherently present in embodiments described in the specification as originally filed and explicitly shown in the Figures as originally filed. No new matter has been added to the application.

### Preliminary Remarks

The following general remarks are presented in the hope that they will facilitate understanding of the claimed invention, the profound differences between it and the cited prior art, and the specific remarks and counterarguments that follow hereinbelow in response to specific Examiner rejections. Exhibits 1 through 5 are provided at the end of this document.

Any optical apparatus may be characterized by its input(s), its internal operation, and its output(s). In all of these respects, the optical apparatus disclosed by George et al. (U. S. Patent 4,834,474) is fundamentally and profoundly different from the optical apparatus disclosed and claimed by the Applicant (Mossberg) in the present application.

#### **1. Nomenclature.**

It must first be pointed out that the understanding of the two disclosed devices (George and Mossberg) is complicated by an unfortunate incongruence in terminology. Several terms of crucial importance are used to mean entirely different things in the two disclosures.

In Exhibit 1, which reproduces a portion of George's Figure 3, a crucial difference in terminology is highlighted. George calls the recording material a holographic element or a diffractive element. To George a "diffractive element" or "element" comprises an entire hologram (shown in the various Figures of George as a thin sheet edge on; for example, items 10 and 12 as labeled in the Figures of George). His nomenclature is discussed, for example, in column 1 lines 20-24 and column 3 lines 20-28. George considers his diffractive elements as comprising a recording of an interference pattern

formed by overlapping coherent waves (column 3 lines 1-7). The interference pattern comprises fringes. Mossberg uses the phrase diffractive element (page 5 lines 23-25) to mean something most closely identifiable with a single fringe of George's diffractive element, but most definitely not George's diffractive element. Mossberg defines diffractive elements in analogy to the individual grooves or lines of a diffraction grating. Use of the terms "element" and "diffractive element" in the two disclosures refer to fundamentally different structural features. Statements employing these terms in the two disclosures may therefore sound similar, but by virtue of these differing definitions will mean profoundly different things and must not be confused.

Another phrase used in both disclosures but defined explicitly (Mossberg: page 9 line 31, page 10 lines 1-5) or implicitly (George: Figures 1-32) to be different is "volume hologram." In George, the volume hologram is depicted as a thin transmissive or reflective sheet used to deflect optical signals so that *path differentials accrued outside the hologram* provide temporal shaping effects. In Mossberg, volume hologram refers to diffractive structures having sufficient depth to allow for *path differentials entirely within the volume hologram* to provide for temporal shaping and spectral filtering function. The implications of the difference are profound as will be highlighted below.

## 2. Device Input, Operation, and Output

George teaches a family of devices wherein one of two things happen to alter the input temporal waveform: spatial wavefront splitting, or spectral pulse splitting.

(2a) Spatial Wavefront Splitting. Different spatial regions of an input pulse are directed by thin holographic sheets (George's diffractive elements or holographic elements) to propagate through differing optical path lengths – exterior to the hologram. This situation is shown in Exhibit 2 which reproduces George's Figure 1b and details how a light pulse propagates as a function of time while interacting with what George calls the curved holographic or diffractive element. The input is a spatially spread beam. At the bottom of Exhibit 2, the final output pulse is shown. Its spatial length is equal to the free-space optical path difference traveled by opposite sides of the input pulse spatial wavefront. To those familiar with the art, it is clear that such a spatially distributed output pulse is poorly suited for coupling into a single-mode channel or fiber, which is undoubtedly why George does not teach such use. Using spatial wavefront splitting, input pulses must be *spatially elongated* and output pulses *move from side-to-side* as a function of time. Put another way, a small area photodetector used to sample portions of the output spatial wavefront would yield an output signal substantially similar

to the input signal (e.g., a single input pulse would yield a single output pulse of similar duration). The relative timing of these single output pulses varies across the output spatial wavefront. The apparatus of George does not result in an altered output temporal waveform that is substantially uniform across the output spatial wavefront.

(2b) Spectral Pulse Splitting. In various embodiments disclosed in George, different frequency components of an input pulse are angularly separated, configured to transit frequency-dependent optical path lengths lying outside of the associated curved holographic/diffractive elements, and recombined to form an output pulse that must in principle possess a variation in frequency as a function of time. This mechanism is shown in Exhibit 3 which reproduces a portion of George's Figure 14. The necessary and intrinsic frequency-variation-versus-time attribute of the output pulse makes it undesirable for spectrally efficient optical communications applications. Using spectral pulse splitting, input pulses must have *excess bandwidth* compared to transform-limited temporally shaped output pulse requirements and output pulses *exhibit a chirp (wavelength ramp) versus time*. Put another way, a spectrometer and photodetector used to sample portions of the output spectral profile would yield an output signal substantially similar to the input signal (e.g., a single input pulse would yield a single output pulse). The relative timing of these single output pulses varies across the output spectral profile. The apparatus of George does not result in an altered output temporal waveform that is substantially uniform across the output spectral profile.

It should be noted that George's fringes (i.e., Mossberg's diffractive elements) are not discussed by George in the context of Exhibits 2 and 3 detailing device operation. George's discussion of diffractive or holographic elements relates to the thin holographic sheets – not to the fringes that reside within the sheets.

In stark contrast, the present application of Mossberg teaches an entirely different type of optical apparatus.

In Exhibit 4, Figures 8 and 10 of the present application are reproduced. Figure 8 clearly delineates the entry of an optical signal into an input port and the emergence of an output signal from an output port. The input and output ports are clearly shown to be connected to a planar waveguide structure. It is stated (page 13 lines 28-31) that

An input optical signal expands from the fiber or waveguide input port 804 as shown. As it propagates, it is diffracted backwards and focused onto the output port 806. The back

diffraction process acts further to apply the design spectral transfer function.

In view of the fact that Mossberg restricts discussion to fully coherent spectral transfer functions (page 3 lines 8-10), the application of a design spectral transfer function is equivalent and synonymous to a specific pulse-shaping operation.

Figure 10 of the present application schematically depicts the interior arrangement of the device of Figure 8. The curved lines indicated, referred to by Mossberg as diffractive elements, would be referred to by George as "fringes" or "grating lines." Combining the information explicitly displayed in Figures 8 and 10 shown in Exhibit 4, it is clear to one skilled in the art how the Mossberg invention functions. Each arcuate segment (defined by Mossberg to be a diffractive element) back diffracts a copy of the input signal and directs it to the output port. Each arcuate segment produces a copy of essentially the entire input pulse signal (temporal, spectral, and spatial) - not a spatial or spectral sub-portion. The output signal ultimately consists of spatially superimposed but temporally shifted copies of the input signal pulse. Control of the spacing, amplitude, and phase of the arcuate segments (diffractive elements) allows for the control over the temporal and spectral properties of the final output pulse – representing as it does a sum over temporally displaced but otherwise spatially superimposed copies of the input signal pulse. Input pulses required do not need excess bandwidth or elongated spatial extent. Output pulses are do not exhibit side-to-side motion or a frequency chirp. Internally, all temporal displacements occur due to optical path differences *entirely within* the volume hologram.

Exhibit 5 further illustrates (schematically) the very different operating principles of the devices of George and Mossberg. In the upper portion of Exhibit 5 is shown a schematic functional diagram of the George apparatus. Paired upper and lower reflectors in the diagram schematically represent the fringes or lines within the volume holographic grating of George. A transversely expanded input waveform is incident upon a volume holographic grating (element 12 of Fig. 1b, for example), with differing portions of the input spatial waveform propagating over differing distances outside the grating. Differing portions of the output spatial waveform also propagate over differing distances outside the grating. These differing propagation distances translate into an altered temporal profile that varies across the spatial waveform of the output signal. Any given portion of the output temporal waveform includes a contribution from only one corresponding portion of the input spatial waveform, and any given portion of the output

spatial wavefront contributes to only one corresponding portion of the output temporal waveform.

The lower portion of Exhibit 5 is a functional schematic diagram of the Mossberg apparatus. Paired upper and lower reflectors in the diagram schematically represent diffractive elements of the volume hologram of Mossberg. No transverse expansion of the input spatial wavefront is necessary, and there is no division of the spatial wavefront. The entire input spatial wavefront interacts with each diffractive element within the volume hologram, and temporal delays arise from propagation within the volume hologram. The output temporal waveform is substantially uniform across the output spatial wavefront. Any given portion of the output temporal waveform includes contributions from a plurality of portions of the input spatial wavefront, and any given portion of the output spatial wavefront contributes to a plurality of portions of the output temporal waveform.

The Mossberg and George inventions therefore differ in key ways in terms of required input, provided output, and internal operation to convert the input to the output.

In the present application (page 7 lines 9-24), reference to and discussion of fiber Bragg gratings is provided. Fiber Bragg gratings are simple one-dimensional devices with input, output, and internal operation in some ways analogous to that of the apparatus of the present application – but which are essentially and profoundly different from that of the George invention.

Various additional embodiments of the device of Exhibit 4 are presented in the pending application, and they also differ fundamentally from the George apparatus as discussed hereinabove.

#### **Claim-specific Remarks**

Examiner has rejected Claims 106, 107, 111, 112, 116, 117, 122, 123, 135, and 136 under 35 USC §112 first paragraph as failing to comply with the written description requirement. Examiner has asserted that the specification does not recite that each portion of the second or output temporal waveform includes contributions from a plurality of portions of the first spatial wavefront, or that each portion of the second or output spatial wavefront contributes to a plurality of portions of the second or output temporal waveform. Examiner has further asserted that such recitation constitutes new matter.

The rejections are believed overcome, since the specification, as amended, now contains a description of the limitations recited in the claims. The description was added in the amended paragraphs beginning on page 13 line 24 and page 15 line 25. Claims 106, 107, 111, 112, 116, 117, 122, 123, 135, and 136 therefore comply with the written description requirement of 35 USC § 112 first paragraph.

The Examiner has asserted such a recitation is new matter. Applicant respectfully disagrees. The added material in the amended paragraphs of the specification merely recite inherent properties and operation of embodiments as originally described in the specification, such inherency being well understood by those skilled in the art. In addition to the inherency of the recited properties and operation as originally described, these are also explicitly shown in the Figures as originally filed. Specifically, Figs. 8, 9A, 9B, and 12 all show quite explicitly that each portion of the second or output temporal waveform includes contributions from a plurality of portions of the first spatial waveform, or that each portion of the second or output spatial waveform contributes to a plurality of portions of the second or output temporal waveform.

Examiner has rejected Claims 12, 13, 16, 18, 19, 23, 24, 34, 35, 45-54, 106, 107, 111, 112, 116, 117, and 134-136 under 35 USC §102(b) as being anticipated by George (US4834474).

The rejections are overcome since it is believed that Claims 12, 13, 16, 18, 19, 23, 24, 34, 35, 45-54, 106, 107, 111, 112, 116, 117, and 134-136, as presented herein, patentably distinguish over George.

Regarding Claims 12, 34, 45, and 134, Applicant reiterates the argument of the Response of 05/15/2003, in light of the Preliminary Remarks set forth hereinabove. Examiner has asserted that George discloses (Figs. 1b, 2b, and 4b; column 2 lines 47-65 and column 5 lines 22-41) a volume hologram comprising a plurality of diffractive elements. Applicant respectfully disagrees. From page 9 line 23 through page 10 line 10 of the specification (the first paragraph of the Detailed Description), Applicant has acted as his own lexicographer and very explicitly set forth a definition for the term "volume hologram". As set forth in the specification, a volume hologram

is a diffractive structure operative to generate output optical signals in response to input optical signals, wherein each portion of the wavefront of the input signal contributes to the

output signal by scattering from the diffractive structure **as it propagates through the structure over a distance large enough so that retardation effects within the diffractive structure significantly influence the form of the output signal.** (emphasis added)

Firstly, recitation of limitations from this definition of volume hologram have now been explicitly included in amended Claims 12, 34, 45, 121, and 134, to better reflect what Applicant intends to claim as the invention.

The “volume transmission holographic element” 12 of Figs. 1b, 2b, and 4b of George does not meet this definition, despite the use of the words “volume” and “holographic”. The element 12 (the entire hologram, not individual fringes thereof) of George acts as a diffraction grating, and has a curved surface. Input signals are diffracted and redirected upon transmission through and/or reflection from the diffraction grating. However, retardation effects **within** the diffractive structure have **no influence** on the temporal form of the output signal. There are in fact no such retardation effects within any diffractive structure disclosed by George. In the George patent, the temporal form of the output signal arises from position- and/or wavelength-dependent differences in propagation distance **outside** the diffractive structure.

Examiner has asserted in the Response to Arguments that George discloses these limitations at column 5 lines 36-39 (“curves introduced into the holographic element 12 are mapped into spatially varying temporal delays in the diffracted pulse”) and column 7 lines 56-61 (“Again element curvatures are used to impart programmable spatially-varying temporal delays in the incident pulse. A feature of this delay line is the variability in spectral and angular bandwidth which may be imparted by the fringe pattern of the volume holographic element structure”). Keeping in mind the differing uses of the word “element” in George and the present application, these passages support Applicant’s position that retardation effects **within** the diffractive structure have **no influence** on the form of the output signal. As carefully explained in the Preliminary Remarks and shown in Exhibits 2 and 3, the “curves introduced into the holographic element 12” result in differing propagation distances **outside the element** for differing portions of the spatial waveform. These differing propagation distances, and nothing else, are what yield an altered output temporal waveform from the device of George. In the second of these cited passages, George even specifically mentions “spectral and angular bandwidth ... imparted by the fringe pattern”, but does not recite any influence

of the fringe pattern on the temporal waveform. There is none. The fringe pattern in the device of George only determines the direction of propagation of the output spatial wavefront; it has no influence over the output temporal waveform. The output temporal waveform in George, to reiterate, is determined by the propagation distances outside the holographic element, which may be influenced by the curvature of the whole holographic element, but not by the fringes thereof.

Accordingly, George discloses no element that meets the definition set forth in the specification for a “volume hologram”. Nor is there any recitation in George of each portion of the first/input spatial wavefront contributing to the output optical signal by scattering from the diffractive elements during propagation through the apparatus over a distance large enough so that temporal retardation effects within a volume of the apparatus occupied by the diffractive elements transform the first/input temporal waveform into the second/output temporal waveform. Since these elements/limitations of Claims 12, 34, 45, and 134 are not disclosed by George, Applicant respectfully submits a rejection under 35 USC §102 is improper. Since there is no suggestion or motivation in George for using a structure meeting the definition of “volume hologram” or the additional limitations thereof, Applicant respectfully submits any rejection under 35 USC §103 in view of George would also be improper.

Regarding Claims 16 and 54, Examiner has asserted that “the recitation that the volume hologram is an optical waveform cross correlator is an inherent teaching of this device. This is because in a volume hologram two inputs (object beam, reference beam) are cross correlated to each other that is, the interference fringes of the volume hologram have to be defined by a cross-correlation of the two beams”. Applicant must respectfully point out that these statements are erroneous. As understood by those skilled in the art, an interference pattern is defined as the result of a coherent linear superposition of two input fields (i.e., the input fields are added with a well-defined relative phase). A cross correlation is defined as a temporal integral of the product of two time-shifted input fields (i.e., the input fields are time-shifted, multiplied together, and the result integrated to yield a cross correlation as a function of the time shift). These are very different mathematical objects, and cannot be interchanged in any meaningful way. Applicant therefore maintains the assertion that George does not disclose anything that may be construed as an optical waveform cross correlator. Since elements and/or limitations of Claims 16 and 54 are not disclosed by George, Applicant respectfully submits a rejection under 35 USC §102 is improper. Since there is no suggestion or motivation in George for employing elements and/or limitations of Claims

16 and 54, Applicant respectfully submits any rejection under 35 USC §103 in view of George would also be improper.

Regarding Claims 18-19 and 24, Examiner has asserted that George discloses diffractive element contours that are circular, elliptical, concentric, and/or confocal (Figs. 1b, 2b, and 4b; column 3 lines 26-29; column 5 lines 36-39; column 7 lines 56-61). Applicant respectfully disagrees. First, as explained hereinabove in the Preliminary Remarks, there has been confusion as to the use of the term "element". The elements referred to in the claim are equivalent to the fringes of the embodiments of George. The views in the Figures cited by the Examiner show the volume holographic diffraction gratings ("elements" as the term is used by George) end-on, and therefore reveal nothing of the shape of the corresponding contours (i.e., the "fringes" of George, equivalent to the "elements" recited in the Claims). The cited text, in fact the entire George patent, is silent as to the shape of the contours of the fringes, other than to disclose sets of parallel straight lines. Nowhere in the George patent is there any disclosure of fringe contours that are circular, elliptical, concentric, or confocal. Since elements and/or limitations of Claims 18-19 and 24 are not disclosed by George, Applicant respectfully submits a rejection under 35 USC §102 is improper. Since there is no suggestion or motivation in George for employing elements and/or limitations of Claims 18-19 and 24, Applicant respectfully submits any rejection under 35 USC §103 in view of George would also be improper.

Regarding Claims 106-107, 111-112, 116-117, and 135-136, Examiner has asserted that George teaches that each portion of the second or output temporal waveform includes contributions from a plurality of portions of the first spatial waveform (Figures 1a/1b and column 5 lines 22-41), and that George teaches that each portion of the second or output spatial waveform contributes to a plurality of portions of the second temporal waveform (Figures 1a/1b and column 5 lines 22-41). However, George does not in fact disclose these limitations, which are inherent in the claimed invention, are explicitly disclosed in the Specification as amended and the Figures as originally filed, and are a fundamental difference between the claimed invention and the disclosure of George. As clearly shown and described in George (Figs. 1a/1b, 2a/2b, and 4a/4b, for example, and others), as well as in Exhibits 2 and 3 and the Preliminary Remarks, the embodiments of George operate by division of the input spatial waveform and differing propagation distances for the divided spatial waveform portions (the differing propagation distances being outside the "volume transmission holographic element"). Each portion of the input spatial waveform is mapped by the device of George onto only

a single corresponding portion of the output temporal waveform. In stark contrast, there is no such division of the input spatial wavefront in the claimed invention. Each portion of the input spatial wavefront incident on the volume hologram so as to contribute to the output spatial wavefront contributes to multiple portions of the output temporal waveform, and each portion of the output temporal waveform includes contributions from multiple portions of the output spatial wavefront. Since elements and/or limitations of the claims in question are not disclosed in George, any rejection under 35 USC §102 would be improper. Since there is no suggestion or motivation for such operation in George, Applicant respectfully submits any rejection under 35 USC §103 in view of George would be improper.

Examiner has rejected Claims 14, 15, 20, 25, 108-110, 113-115, 118-120, and 121-133 under 35 USC §103(a) as unpatentable over George (US4834474) in view of Weverka (US5165104).

The rejections are overcome since it is believed that Claims 14, 15, 20, 25, 108-110, 113-115, 118-120, and 121-133, as presented herein, patentably distinguish over George and Weverka.

With regard to Claim 121, Applicant respectfully submits that elements and/or limitations of the claim in question are not disclosed, suggested, or motivated by George or Weverka, for the reasons stated hereinabove for Claims 12, 34, 45, and 134. Therefore, rejection of Claim 121 under 35 USC 103(a) is improper and should be withdrawn.

With regard to Claims 122-123, Applicant respectfully submits that elements and/or limitations of the claims in question are not disclosed, suggested, or motivated by George or Weverka, for the reasons stated hereinabove for Claims 106-107, 111-112, 116-117, and 135-136. Therefore, rejection of Claim 122-123 under 35 USC 103(a) is improper and should be withdrawn.

With regard to Claims 128-129 and 132, Applicant respectfully submits that elements and/or limitations of the claims in question are not disclosed, suggested, or motivated by George or Weverka, for the reasons stated hereinabove for Claims 18-19 and 24. Therefore, rejection of Claim 128-129 and 132 under 35 USC 103(a) is improper and should be withdrawn.

With regard to Claim 127, Applicant respectfully submits that elements and/or limitations of the claim in question are not disclosed, suggested, or motivated by George

or Weverka, for the reasons stated hereinabove for Claims 16 and 54. Therefore, rejection of Claim 127 under 35 USC 103(a) is improper and should be withdrawn.

Regarding Claims 14-15, 20, 25, and 106-133, George does not disclose a volume hologram residing within a planar optical waveguide, nor does George disclose interaction of the input signal with the volume hologram while the input signal propagates within the planar waveguide, the propagation of the input optical signal within the planar waveguide being substantially guided in at least one dimension by the planar waveguide. Neither does George disclose input and output optical waveguides. Weverka discloses propagation of optical signals within a planar waveguide and input and output optical waveguides, as well as redirection of optical signals within the planar waveguide using acousto-optically generated Bragg diffraction gratings. However, there can be no motivation to combine the teachings of George and Weverka. The very essence of the George invention is precise control over the output temporal waveform through alteration of the shape of the holographic grating, thereby altering the optical propagation distance traversed by various portions of the spatial wavefront outside the grating. Acousto-optically generated Bragg diffraction gratings are employed in the device of Weverka to redirect optical signals within a planar waveguide. However, by its very nature (i.e., a sound wave propagating through a continuous medium) the precise shape of the acousto-optically generated grating within the waveguide cannot be controlled with precision. An acousto-optically generated Bragg grating therefore cannot be incorporated into the device of George to achieve control over the output temporal waveform. Combination of the teachings of these two references would result in a device inoperable for its intended purpose. Any rejection of a claim under 35 USC §103 based on a combination of these references is therefore improper, and should be withdrawn (*In re Gordon*, 733 F.2d 900, 221 USPQ 1125).

Newly presented Claims 134-136 are believed to be generic to elected Species 2 and non-elected Species 1, 3, and 4 of elected Group I. Claims 12-16, 18-25, 34-35, 45-54, and 106-133 are drawn to elected Species 2. In the event that one or more of Claims 134-136 is held allowable, Applicant respectfully requests reinstatement and allowance of Claims 1-11, 26-33, and 36-44 (Species 1), Claims 87-103 (Species 3), and Claims 104-105 (Species 4).

In view of the above, Applicant respectfully submits that Claims 12-16, 18-25, 34-35, 45-54, and 106-136 are in condition for allowance. Reconsideration of the rejections is respectfully requested. Allowance of Claims 12-16, 18-25, 34-35, 45-54,

and 106-136, and reinstatement and allowance of Claims 1-11, 26-33, 36-44, and 87-105, are earnestly solicited.

Respectfully submitted,

MSL